

Effects of extraction from nymphs, exuviae and adults of *Bemisia tabaci* B biotype on the behavior of *Encarsia bimaculata* Heraty *et* Polaszek (Hymenoptera: Aphelinidae)

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Abstract: The response of female *Encarsia bimaculata* Heraty *et* Polaszek to its host, *Bemisia tabaci* (Gennadius) nymph, exuviae or adult extractions was bioassayed in a petri dish arena. The tested materials were extracted by hexane, ethanol and water. The data show that females spent much longer times searching in treated patches than controls. The parasitoids intensified their search in the treated patches and exhibited both orthokinetic and klinotactic responses. The highest mean of the retention time in the treated patches was in those treated with material extracted from nymphs with water (111.23 seconds), otherwise parasitoids spent equal time in treated patches irrespective of the concentrations of the tested materials. Such kairomones might enhance female searching efficiency and guide them to hosts.

Key words: *Encarsia bimaculata*; *Bemisia tabaci*; parasitoids; kairomones; arrestment response; host location

1 INTRODUCTION

Parasitoids can greatly increase their efficiency of searching for hosts if they concentrate their efforts in those sites or patches that are likely contain their hosts (Zaborski *et al.*, 1987). The olfactory cues eliciting the searching process may originate from the host plant (synomones), host (kairomones), associated organisms (apneumones) or a combination of host plant and host (host-plant complex) (Vet and Dick, 1992). Previous studies have demonstrated that kairomones from honeydew (Shimaron *et al.*, 1992), exuviae (Battaglia *et al.*, 2000), and host individuals (Singh and Srivastava, 1989) might play an important role in guiding the natural enemies to hosts/preys.

Bemisia tabaci has become a serious worldwide pest of vegetables, ornamentals and field crops. In Guangdong Province, South China, *B. tabaci* has replaced the greenhouse whitefly and become the domi-

nant whitefly species (Qiu, 2002). *Encarsia bimaculata* Heraty *et* Polaszek is found to be one of the most common and effective parasitoids of *B. tabaci* in Guangdong Province; accounting for 32.33% of total parasitism (Qiu, 2002). However, little is known about how this parasitoid finds its host. In this paper, we characterized the arrestment responses of *E. bimaculata* to different kairomonal extractions from nymphs, exuviae, and adults of its host, *B. tabaci* B biotype.

2 MATERIALS AND METHODS

2.1 Whitefly and parasitoid colony

A colony of sweetpotato whitefly, *B. tabaci* type B was established on poinsettia plants in a controlled environment room at a photoperiod of 16:8 (L:D) h; $(25 \pm 2)^\circ\text{C}$ and $60\% \pm 10\%$ RH. Infested poinsettia plants with the second and third whitefly nymphal instars were subjected to parasitization by *E. bimaculata* in another air-conditioned room.

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2.2 Experiments

To study the effects of different extracts from *B. tabaci* B biotype exuviae, nymphs and adults on the arrestment responses and retention time of parasitoids, fresh exuviae, nymphs (1st – 4th instar), and adults were collected from the infested plants. Exuviae and nymphs were collected using a fine insect pin, while an aspirator was used to collect adults. Collected nymphs, adults, or exuviae were transferred separately to vials containing 1.0 mL of hexane, ethyl alcohol or doubled distilled water for 6 h. Solutions were then filtered, sealed in vials and stored at – 4°C in refrigerator until needed. Two concentrations of each extract, 100 and 200 nymphs, exuviae or adults/mL solvent, from each kind of material were studied.

The retention time of the parasitoids was studied in an observation arena consisting of a 12 cm diameter petri dish containing an 11 cm filter paper disc treated with the nymph, adult or exuviae extractions. Treated areas were ringed with pencil and two concentric circles (4 and 7 cm diameter) were drawn (Zaborski *et al.*, 1987). 100 μL of each concentration were applied as circular spots in the treatment areas and allowed to dry completely. Tests started by releasing a single female parasitoid in the middle of the treated area, covering the Petri dish and recording her movements, retention time in the treated area, and neighboring area with a stop watch for 10 minutes. The number of re-entries of the treated area by female parasitoids was also recorded. Each treatment was carried out 3 times with total of 30 wasps.

The parasitoids used in these experiments were 24 – 48 h old and had been collected by aspirator and confined in 10 cm × 2 cm diameter glass tube with some droplets of honey solution on the inner wall as food. Before experiments, parasitoids were confined in 2 cm × 0.5 cm diameter glass vials with small droplet of honey solution and covered with a piece of clean cotton, and then sorted out under binocular microscope. Each parasitoid was used only once and each trial was terminated when the parasitoid left the outer boarder of the neighboring area or when it started to fly to the sides or the top of the petri dish (Zaborski *et al.*, 1987).

2.3 Statistical analysis

Data for different extractions and concentrations were compared with an ANOVA and, if found significant, by the Duncan multiple range test (SAS Institute, 1988).

3 RESULTS

General observations on the behavior of *E. bimaculata* on treated patches indicated that the tested materials elicited an arrestment response. In the presence of the tested materials, the parasitoid moved slowly and spent much time searching in both treated and neighboring area. Moreover, it returned to the treated patch when it lost contact with tested chemicals. However, in control treatments (water, ethanol and hexane), the parasitoid moved over the treated patch quickly and spent much time walking on or flying to the surface of the petri dish.

The arrestant chemicals found in *B. tabaci* type B nymphs seem to be water and ethanol extractable; however, parasitoid's response to material extracted with hexane was not different of that of control treatments. The strongest arrestment response was elicited by water extracted material and intensity of the response increased with increasing concentration (Table 1). However, the number of re-entries to the treated patch and searching time in the neighboring area were only significantly different to the control in case of ethanol extracts.

Table 1 Average search time (seconds) spent by *Encarsia bimaculata* on filter paper treated with different *Bemisia tabaci* nymph extracts

Treatments	n	Search time (s) (Mean ± SE)		Re-entries
		Treated area	Neighboring area	(Mean ± SE)
Water				
Control	30	17.44 ± 1.52 a	6.36 ± 2.78 a	0.07 ± 0.04 a
100/mL	30	49.20 ± 9.73 b	8.26 ± 2.19 a	0.23 ± 0.12 a
200/mL	30	111.23 ± 15.40 c	6.33 ± 1.95 a	0.31 ± 0.12 a
n-Hexane				
Control	30	14.90 ± 2.60 a	3.80 ± 1.42 a	0.00 ± 0.00 a
100/mL	30	20.48 ± 6.36 a	3.32 ± 0.96 a	0.00 ± 0.00 a
200/mL	30	19.20 ± 3.02 a	4.24 ± 1.47 a	0.00 ± 0.00 a
Alcohol				
Control	30	19.17 ± 3.09 a	1.70 ± 0.25 a	0.00 ± 0.00 a
100/mL	30	51.88 ± 8.67 b	9.30 ± 2.06 b	0.40 ± 0.18 b
200/mL	30	53.86 ± 8.97 b	11.00 ± 2.06 b	0.40 ± 0.10 b

Means followed by the same letters in the same column are not significantly different (Duncan 0.05)

The kairomones in *B. tabaci* exuviae were water, ethanol, and hexane extractable. The retention times in treated patches for all exuviae extracts were higher and significantly different to that in neighboring area and controls (Table 2). Search time also increased with increasing concentration. Searching time in neighboring area was significantly different to control in the case of both hexane and ethanol extractions. However, water extracts elicited a significantly number of re-entries than the control.

Table 2 Average search time (seconds) spent by *Encarsia bimaculata* on filter paper treated with different *Bemisia tabaci* exuviae extracts

Treatments	n	Search time (s) (Mean \pm SE)		Re-entries
		Treated area	Neighboring area	(Mean \pm SE)
Water				
Control	30	17.44 \pm 1.52 a	6.36 \pm 2.78 a	0.07 \pm 0.04 a
100/mL	25	73.96 \pm 17.27 b	11.16 \pm 2.34 a	0.20 \pm 0.13 ab
200/mL	25	72.40 \pm 22.66 b	11.20 \pm 2.89 a	0.44 \pm 0.15 b
n-Hexane				
Control	30	14.90 \pm 2.60 a	3.80 \pm 1.42 a	0.00 \pm 0.00 a
100/mL	30	33.13 \pm 5.49 b	12.366 \pm 2.66 b	0.33 \pm 0.16 a
200/mL	30	36.70 \pm 8.39 b	8.10 \pm 1.93 ab	0.36 \pm 0.12 a
Alcohol				
Control	30	19.16 \pm 3.09 a	1.70 \pm 0.55 a	0.03 \pm 0.03 a
100/mL	30	29.53 \pm 8.72 ab	5.87 \pm 1.29 a	0.15 \pm 0.13 a
200/mL	30	48.87 \pm 13.17 b	13.28 \pm 2.82 b	0.22 \pm 0.11 a

Means followed by the same letters in the same column are not significantly different (Duncan 0.05)

Table 3 Average search time (seconds) spent by *Encarsia bimaculata* on filter paper treated with different *Bemisia tabaci* adult extracts.

Treatments	n	Search time (s) (Mean ± SE)		Re-entries
		Treated area	Neighboring area	(Mean ± SE)
Water				
Control	30	17.44 ± 1.52 a	6.36 ± 2.78 a	0.07 ± 0.04 a
100/mL	30	19.36 ± 1.99 a	1.96 ± 1.06 a	0.00 ± 0.00 a
200/mL	30	24.83 ± 4.88 a	3.26 ± 1.65 a	0.17 ± 0.11 a
n-Hexane				
Control	30	14.90 ± 2.60 a	3.80 ± 1.42 a	0.00 ± 0.00 a
100/mL	30	21.70 ± 2.60 a	6.13 ± 2.93 a	0.30 ± 0.26 a
200/mL	30	23.93 ± 3.40 a	3.43 ± 1.22 a	0.07 ± 0.04 a
Alcohol				
Control	30	19.17 ± 3.09 a	1.70 ± 0.25 a	0.00 ± 0.00 a
100/mL	30	46.52 ± 15.67 b	6.52 ± 1.82 b	0.15 ± 0.12 a
200/mL	30	29.04 ± 3.11 ab	2.61 ± 1.08 a	0.00 ± 0.00 a

Means followed by the same letters in the same column are not significantly different (Duncan 0.05)

In case of adult extracts, the arrestant chemicals were only ethanol extractable (Table 3). Neither searching time in the neighboring area nor the number of re-entries were significantly different in all extraction methods.

4 DISCUSSION

Naturally occurring *B. tabaci* populations are often accompanied by a patch of nymphs, exuviae or died adults and the arrestment of the parasitoids in such patches could allow them to concentrate their search efforts in locations where they are more likely to encounter their hosts. In general, except in the case of water extracted nymph materials, *E. bimaculata* spent equal time in all treated patches irrespective of the concentrations used. Such behavior has also been reported in *Trichogramma minutum* (Zaborski *et al.*, 1987) and *Encarsia deserti* (Shimaron *et al.*, 1992).

E. bimaculata displayed a stronger and more reliable response to extracts with sessile stages of its host (nymphs or exuviae) than the mobile stage (adults), which is consistent with the fact that its probability of locating adults *B. tabaci* in nature is somewhat weak. Many studies report the use of the host as a kairomone resource by natural enemies; for example, females of *Tirioxys indicus* are attracted to aqueous extracts of *Aphis craccivora* (Singh and Srivastava, 1989) and the encyrtids, *Acerophagus coccois* and *Aenasius vexans*, are attracted to kairomone from *Phenacoccus herreni* (Calatayud *et al.*, 2001). *E. bimaculata* also used exuviae of its host as a kairomone source and the active ingredients (kairomones) in this exuviae were water and hexane extractable. Several studies report that exuviae act as a kairomone source for parasitoids. For instance, *Amitus longiconis* responded positively to exuviae of *Aleurocanthus spiniferus* (Li *et al.*, 1993), and *Aphidius ervi* exhibited ovipositional reactions to exuviae of *Acyrtosiphon pisum* (Battaglia *et al.*, 2000). Thereby, it might be possible to increase the searching efficiency of the *E. bimaculata* through manipulation of its host location behaviour, which might enhance the biological control of *B. tabaci*.

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烟粉虱 B 生物型若虫、皮蛻及成虫提取物 对双斑蚜小蜂行为的影响

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摘要: 烟粉虱 B 生物型的若虫、皮蛻及其成虫的提取物作为一种利它素信息源, 在室内对其在双斑蚜小蜂寻找寄主取食、寄生行为的影响进行了生物测定。烟粉虱的若虫、皮蛻及其成虫分别用正己烷、乙醇和无菌水进行粗提。研究结果发现, 双斑蚜小蜂在处理区寻找寄主停留的时间高于对照区。在处理区, 双斑蚜小蜂行动活泼, 对利它素源表现出高的正趋向性和选择性。对于同一利它素源、同一提取介质的两种不同浓度, 双斑蚜小蜂在若虫-水提取物的高浓度区停留的时间(111.23 s)最长, 与在低浓度区的停留时间差异显著; 而在烟粉虱皮蛻及其成虫的水、正己烷和乙醇提取物处理区, 不同浓度的提取物对蚜小蜂停留的时间影响差异不显著。本研究的结果表明, 利它素可以增加蚜小蜂寻找寄主的效率, 有利于蚜小蜂寻找到适宜的寄主。

关键词: 双斑蚜小蜂; 烟粉虱; 拟寄生物; 利它素; 寄主定位

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